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779486

TECHNICAL REPORT

74-43-FL

10/13

**EFFECTS OF PROLONGED FREEZER STORAGE ON  
TEXTURE AND OTHER  
QUALITY CHARACTERISTICS OF TURKEY MEAT**

by

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and

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West Lafayette, Indiana 47907

Contract No.: DAAG17-73-C-0063

April 1974

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**UNITED STATES ARMY  
NATICK LABORATORIES  
Natick, Massachusetts 01760**



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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM															
1. REPORT NUMBER 74-43-FL	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER <b>AD 779 486</b>															
4. TITLE (and Subtitle) EFFECTS OF PROLONGED FREEZER STORAGE ON TEXTURE AND OTHER QUALITY CHARACTERISTICS OF TURKEY MEAT		5. TYPE OF REPORT & PERIOD COVERED Final 4 Jan 1973 - 4 Jan 1974															
		6. PERFORMING ORG. REPORT NUMBER FL-191															
7. AUTHOR(s) W.J. Stadelman D.E. Pratt E.D. Aberle		8. CONTRACT OR GRANT NUMBER(s)  DAAG17-73-C-0063															
9. PERFORMING ORGANIZATION NAME AND ADDRESS Purdue University West Lafayette, Indiana 47907		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS  1T762713A034															
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Natick Laboratories Natick, Massachusetts 01760		12. REPORT DATE April 1974															
		13. NUMBER OF PAGES 19															
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)  UNCLASSIFIED															
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE															
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited																	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)																	
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <u>Link A</u> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Role</th> <th style="text-align: center;">Wt</th> </tr> </thead> <tbody> <tr> <td>Storage</td> <td style="text-align: center;">6</td> <td></td> </tr> <tr> <td>Freezer</td> <td style="text-align: center;">6</td> <td></td> </tr> <tr> <td>Freezing</td> <td style="text-align: center;">6</td> <td></td> </tr> <tr> <td>Meat</td> <td style="text-align: center;">7</td> <td></td> </tr> </tbody> </table> <div style="text-align: right;">(continued)</div>				Role	Wt	Storage	6		Freezer	6		Freezing	6		Meat	7	
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## 19. Key Words

	Link A	
	Role	WT
Turkey	7	
Turkey Meat	7	
Turkey Rolls	7	
Flavor	7	
Texture	7	
Color	7	
Odor	7	
Acceptability	7	

## 20. Abstract

Results indicate that for virtually all parameters tested, roll formulation resulted in the greatest variation in means. The next largest source of variation was the source of turkey meat as to geographic location of processing plant. Within the limits of this study, variation in results attributable to carcass age or roll age were of relatively small magnitude even though many of the parameters measured showed statistically significant variation in the resulting means.

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Contract No. DAAG17-73-C-0063

Project reference:  
1T762713A034

Series: FL-191

April 1974

Food Laboratory  
U. S. ARMY NATICK LABORATORIES  
Natick, Massachusetts 01760

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## FOREWORD

Turkey rolls represent a major item in supplying our Armed Forces. During an eight month period prior to the initiation of this contract 8,824,545 pounds of raw turkey rolls and 1,231,324 pounds of cooked turkey rolls were purchased for troop issue at a total cost of approximately six million dollars. For many years recognition has been given the fact that the ninety day limitation imposed on the frozen storage of the turkeys used for the fabrication of rolls restricted procurement at certain times of the year and resulted in an increase of approximately 12% in cost. As a primary objective this investigation was undertaken to supply evidence on the suitability of turkeys held in frozen storage for periods up to 180 days prior to fabrication into rolls. As a secondary objective this investigation sought to provide comparative information on the acceptability of turkey rolls prepared in accordance with common commercial procedures.

The experimental program herein described was performed at Purdue University with funds provided under Project No. 1T762713A034, titled: Military Food Service and Subsistence Technology. Professor W. J. Stadelman served as Principal Investigator with Fr. D. E. Pratt and Dr. E. D. Aberle acting as collaborators. Dr. Maxwell C. Brockmann and Justin M. Tuomy served as Project Officer and Alternate Project Officer, respectively, for the U. S. Army Natick Laboratories.

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## ABSTRACT

Turkey rolls were prepared according to each of four designated specifications from turkey meat purchased as canner-packed turkey carcasses in Ohio, Indiana and Arkansas. Carcasses were deboned after being held in frozen storage for less than 30 days, 90 days, 130 days and 180 days. Rolls were evaluated after 0, 90 and 180 days of frozen storage. In all, 288 nine-pound rolls were prepared and evaluated for flavor, odor, color, texture and appearance by an organoleptic panel and objectively by a Hunter Color Meter, a Kramer shear cell attached to an Instron Universal Testing Machine and a thiobarbaturic acid test.

Results indicate that for virtually all parameters tested, roll formulation resulted in the greatest variation in means. The next largest source of variation was the source of turkey meat as to geographic location of processing plant. Within the limits of this study, variation in results attributable to carcass age or roll age were of relatively small magnitude even though many of the parameters measured showed statistically significant variation in the resulting means.

## INTRODUCTION

Turkey meat is a significant menu item in military rations. Most turkey as used by military installations is purchased as boneless turkey meat under specification MIL-T-16660D. One requirement in this specification is that all turkey meat at the time of separation from the carcass must not have been in frozen storage for more than 89 days. As turkey production is a seasonal operation, a uniform supply of turkey meat meeting the requirements of the procurement specification is not available.

## OBJECTIVE

This investigation was undertaken to determine the effects on the acceptability and storage behavior of turkey meat prepared as rolls, uncooked and cooked. Turkey carcasses used as a source of meat varied in prior frozen storage from less than 30 days to 180 days. Roll formulations were varied and storage time for rolls ranged from 0 to 180 days.

## PROCEDURE

Turkey carcasses were purchased from commercial sources in three states: Ohio, Indiana and Arkansas. Dates of processing were obtained so that the carcasses could be thawed and deboned after less than 30 days, 90 days, 130 days and 180 days of frozen storage. All turkeys purchased were canner-packed tom turkeys in 0.002 inch polyethylene bags. Turkeys held after purchase to get sufficient time in frozen storage were kept in a commercial refrigerated warehouse at  $-5^{\circ}\text{F}$  ( $-20^{\circ}\text{C}$ ). Each lot of storage turkeys was removed from the freezer several days prior to deboning to allow for thawing in a  $35^{\circ}\text{F}$  cooler. The polyethylene bags were removed just prior to deboning.

In deboning, the first operation was removal of as large a piece of skin from the carcass as possible to be used in preparation of rolls as specified under formula A and C. The breast muscles, pectoralis major and minor, and the thigh muscles were next removed maintaining almost total integrity of each muscle. The white meat, dark meat and skin were kept separate and chilled to  $35^{\circ}\text{F}$  until roll formulation on the following day.

Roll manufacture was accomplished at the Food Research Center, Union Carbide Co., 6830 West 65th Street, Chicago, Illinois, according to the four formulations listed:

- A. Raw turkey logs prepared and packaged in conformance with Type II of MIL-T-16660D dated 7 April 1965 and Amendment-4 dated 2 September 1971, entitled "Turkey, Boneless, Frozen, Raw or Cooked."

Specific requirements for Type II rolls as listed in this specification are:

- 1. A raw, tied roll.
- 2. Additives: 1 pound salt and 1/2 ounce pepper per 100 pounds

- of raw deboned turkey.
3. Finished product requirements:
    - a. Shall be 9-17 inches in length.
    - b. Shall be 4-7 inches in diameter.
    - c. The skin shall cover the entire product as completely as possible and in no case shall the skin covering be less than 75 percent of the total exposed surface area.
    - d. Shall have been tied with cotton twine at intervals of not more than 3 nor less than 2 inches apart around the circumference from one end to the other.
  4. Packaging requirements:
    - a. The product shall be inserted into a bag constructed from one of the materials specified below. The bag shall be closed with a malleable metal clip, or other equivalent method. The bag shall cling tightly to the product as the result of shrinking, vacuumizing or mechanical means, or a combination of two or more of these methods. The bag shall be of sufficient diameter and length to result in a product complying with the applicable size requirements.
    - b. Bags shall be constructed from one of the following materials:
      - (1) A frozen food grade film formed by copolymerizing vinylidene chloride with vinyl chloride. The film shall average not less than 0.0015-inch thick.
      - (2) A shrinkable polyethylene terephthalate film 0.00065-inch nominal thickness.
      - (3) Polyvinyl chloride with suitable food grade plasticizers not less than 0.0020-inch thick.
      - (4) A shrinkable polyethylene 0.001-inch thick; the thickness shall be tested in accordance with L-P-378.

Each batch for the preparation of 6 rolls consisted of 64 pounds turkey meat (42 pounds white meat and 22 pounds dark meat) left in large pieces as removed from the turkey carcass, 290 grams salt (NaCl) and 9 grams pepper.

- B. Cooked turkey logs prepared and packaged in conformance with Type IV of references Specification.

Specific requirements for Type IV rolls according to this specification are:

1. A cooked, encased roll.
2. Additives: 1-1/2 pounds salt, 3/4 ounce pepper and 2 pounds gelatin per 100 pounds of raw deboned turkey.
3. Preparation specifications:
  - a. The product shall have a raw uncooked weight of not less than 9 pounds.
  - b. The formed product shall be cooked in a water bath to an internal temperature of not more than 175°F nor less than 170°F in the thickest part of the product. The temperature of water bath shall not exceed 190°F.

4. Finished product requirements:
  - a. Shall be 12-15 inches in circumference.
  - b. Shall weigh not more than 7 nor less than 6 pounds, drained weight.
  - c. The casing shall be tightened after drainage to encompass the meat to the full diameter, leaving the casing free of wrinkles.
  - d. The product shall remain intact when sliced cold ( $40^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ); slice to be 1/8-inch thick.
  - e. It is not necessary that the skin cover the entire product, however, the skin shall be on the surface next to the casing.
5. Packaging requirements:
  - a. The product shall be stuffed into a regenerated cellulose casing, with reinforcing cellulosic fibers, coated with plastic material to make the casing moisture impermeable. The moisture impermeability shall be tested by placing a section of the casing, exterior side up, on a piece of absorbent paper. Pour a small pool of water ( $60^{\circ}$  to  $80^{\circ}\text{F}$ ) on the center of the test material and let stand for 15 minutes. Examine absorbent paper for damp spots. Absence of moist spots will indicate a moisture impermeable casing material. The diameter and length of the casings shall be sufficient to comply with size limitations. The ends of the casing shall be secured with a malleable metal slip or equivalent method.

Each batch consisted of turkey meat as in A., 435 grams salt, 13.6 grams pepper and 580 grams of gelatin. After mixing and stuffing in casings, these rolls were cooked in hot water ( $180^{\circ}$  to  $190^{\circ}\text{F}$ ) to an internal temperature of  $170^{\circ}\text{F}$  at the center of the roll.

- C. Boneless turkey as used in A above was cut into pieces approximately  $1 \times 1 \times 1/2$  inch which was mixed or tumbled with one percent salt (NaCl) and 0.5 percent of a suitable polymeric phosphate and thence processed and packaged as Type II raw turkey logs cited in A above. Each batch consisted of turkey meat, salt and pepper as in A above and 145 grams of a commercial polyphosphate mixture (Kena).
- D. Eighty-eight (88) parts of boneless turkey and seasonings as used in C above, was thoroughly mixed with 12 parts of an emulsion prepared from turkey skin from the same birds. The emulsion contained salt and polymeric phosphate in amounts corresponding to one and five-tenths percents, respectively, of the finished product weight. Except for the absence of skin cover, the mixture of turkey and emulsion shall be processed and packaged the same as formula B above.

With all of the formulations the following procedures were followed:

1. Component materials:
  - a. Turkeys:

- (1) Frozen for number of days specified in report.
  - (2) Young tom or hen turkeys, less than 1 year old of USDA grade B or better, as defined in Regulations Governing the Grading and Inspection of Poultry and Edible Products Thereof and United States Classes, Standards, and Grades with Respect Thereto (7 CFR, part 70).
  - (3) Shall be in sound, wholesome condition with no evidence of off-condition such as off-odor, slightly sticky, etc.
  - (4) The internal temperature at the center of the thigh shall not exceed 40°F at the start of the boning operation.
- b. Salt:
- (1) Salt shall be white refined sodium chloride with or without anticaking agent. Iodized salt shall not be used.
- c. Pepper:
- (1) Shall be ground, white or black pepper complying with Type II of EE-S-631.
- d. Celatin:
- (1) Celatin shall comply with Type I of C-D-221, except that the jel strength shall be 275  $\pm$  10 grams.
2. Formulation processes:
- a. The ingredients shall be uniformly distributed on the surfaces of the meat as the product is being formulated.
3. Finished product requirements:
- a. All types shall be free from pinfeathers, blood clots, and bruises, and bone or hard tendons whose greatest dimension is 1/4-inch or greater.
  - b. A unit shall have at least 50 percent by weight of white meat and not less than 80 percent of the unit shall be whole or halved breasts and thighs.
  - c. The thickness of skin and fat combined shall not exceed 1/4-inch at any point.
  - d. There shall be no loose pieces (tag ends) of skin, muscle tissue, fat, casing, or string which exceeds more than 1/2-inch from the surface of any unit.
  - e. The product shall be arranged so the breast meat is opposite the thigh meat or in alternate layers of dark and light meat, except in formula C and D.
  - f. The product shall contain no ground or comminuted meat or skin, except where specified in formula D.
  - g. The boneless turkey, after being properly packed, shall be placed in a freezer within 4 hours after processing, and frozen to a temperature of 0°F in the thickest part of the product within 72 hours from the completion of processing. After being frozen and until time of delivery, the temperature shall not exceed 0°F in the thickest part of the product. The product shall remain in a sound, wholesome condition in a hard frozen state, and the temperature shall not exceed 0°F, in the thickest part of the

product at destination. The product shall show no evidence of defrosting or refreezing.

- h. The product shall be in sound, wholesome condition with no evidence of off-condition such as off-odor, slightly sticky, etc.

Rolls from each of the three sources and each of the four storage periods for turkeys were prepared on the following dates:

<u>Carcass</u> <u>Storage Period</u>	<u>Source</u>		
	<u>Indiana</u>	<u>Ohio</u>	<u>Arkansas</u>
<u>Days</u>			
30	Mar. 8	Feb. 15	May 31
90	Mar. 8	Mar. 15	Feb. 15
130	Apr. 5	Apr. 24	Feb. 15
180	May 31	June 13	Mar. 8

Following preparation, rolls were chilled and returned to Lafayette, Indiana. Those to be evaluated immediately (two from each of the formulations for each of the above sources and storage times) were delivered to the Foods and Nutrition Department (Dr. Pratt) for preparation prior to evaluation. All other rolls were blast frozen ( $-40^{\circ}\text{F}$ ) and then placed in  $-5^{\circ}\text{F}$  frozen storage for 90 or 180 days.

Eight rolls were removed from frozen storage at time of evaluation, two rolls from each of the 4 formulations, and were thawed. The raw rolls were cooked to an end point of  $170^{\circ}\text{F}$  in a hot air oven set at  $350^{\circ}\text{F}$ ; the precooked rolls were warmed to an internal temperature of  $140^{\circ}\text{F}$ ; and the rolls were cut in half at right angles to the long axis. One half of each roll was then evaluated, while warm, by a taste panel. Circular slices 1 cm in thickness were divided. One half was judged for odor and flavor under masked light filtered through red filters. The other half of the slice was then judged by the panel for color, texture and general appearance under unfiltered, indoor, white light.

Each of the five quality factors was judged on a hedonic scale of 9 with the range from 9 for like extremely to 1 for dislike extremely and a midpoint of 5 for neither like or dislike. A total of eight trained panelists judged each roll.

The opposite half of each roll was further divided into two parts; one for 2-thiobarbituric acid and instrumental color evaluation on  $A_L$  and  $B_L$  scales of a Hunter Color difference meter; and the other for evaluation of texture using an Allo-Kramer shear cell attached to an Instron Universal Testing machine. All TBA tests and color measurements were made on the day the rolls were prepared for evaluation. Measurements of textural characteristics were made on the meat after the product had cooled to  $35^{\circ}\text{F}$  but within 24 hours of roll preparation for evaluation.

## RESULTS AND DISCUSSION

A total of 288 turkey rolls, 72 from each of four recipes, were prepared, stored and evaluated by subjective means for flavor, odor, texture, appearance, and color. Mean scores for the main production variables are listed in Table I with a summary of the analyses of variance for each factor listed in Table II. The error term used for determining statistical significance was the combined sum of squares for third and fourth order interactions. The residual mean square is an indication of capability of the taste panel in uniformity of scoring duplicate rolls. This is also shown by mean values for duplicates with the greatest difference between duplicates being 0.09 points on a 9 point scale or 1%.

As expected, the roll formula variance was greatest among the main effects. On flavor, odor and texture the raw rolls, A and C, scored significantly higher than the precooked rolls. The magnitude of this difference suggests the need for modification of formulation on Type IV rolls in the specification MIL-T-16660D.

There were no significant differences in flavor or odor attributable to carcass age comparing carcasses of less than 30 days, 90 days, 130 days and 180 days in frozen storage. There were statistically significant differences in means for texture, appearance and color as viewed by the panel but the extreme values which contributed to this difference were not between the extremes in carcass age so are not considered to be of practical importance.

The source of turkey carcasses showed a low level statistical significance of about the same importance as carcass age. The fact that each carcass age from any source most likely represented a different flock of turkeys would suggest that variation among flocks in any of the three states used for procurement was about equal to variation among states of origin. Based on these results, turkey meat could be purchased from any of the sources with equal expectation of having a satisfactory response from consumers.

The age of the prepared roll had a highly significant effect on all of the organoleptic evaluation scores. The mean scores on rolls for each criterion improved as rolls were held in the freezer for longer periods of time. No absolute explanation for this observation is available. As indicated in Tables III and IV, the TBA values of the rolls did not change during the 180 days of frozen storage so there was no significant rancidity development. A possible explanation might be that as the panelists became more experienced during the course of the study, they developed a liking for turkey. Another possibility might be the existence of a seasonality preference for turkey meat. The explanation of either of these possibilities is shown in Figure 1. The study had to be conducted in this way due to the 12-month limitation for completion of the research. As for experience of the panel, each member selected had had at least eight training sessions. They then evaluated 0-day storage rolls for 9



times before getting 3 sessions with 90-day storage rolls. They had a total of 21 sessions before tasting the first 180-day storage roll. As to seasonality, the question is raised as to whether or not the American consumer subconsciously would score turkey meat higher during fall months than during spring or summer months. The only conclusive statement that can be made from these data is that the quality of turkey rolls did not deteriorate detectably during 180 days of frozen storage.

Data in Tables III and IV relative to TBA values are of interest as they relate to flavor and odor values. The only significant main effect was formula. Formula B roll had especially higher TBA values than the other rolls. This is likely due to it being precooked and that the formulation contained no added antioxidant such as was included in formula D.

Color determinations with the Hunter Color Meter indicate that roll formula D was least bright or white, likely due to the skin emulsion included. There were no differences in degree of red or yellow, A and B scales, respectively, among the four roll formulas. The statistically significant differences in A and B readings are of no practical value as no trends were evident.

Evaluation of texture of the turkey rolls by instrument was with a Kramer shear cell attached to an Instron Universal Testing machine. The readout was directly into a PDP 11 computer for automated data collection. Data were collected relative to the shape and area of the compression - shear - extrusion curves. Samples were cut from each roll 2 cm x 6.6 cm x 0.5 cm and weighed to nearest 0.1 gram. Data are reported in Tables V and VI relating to the slopes of the compression curve and the shear curve. All values were statistically significantly different. Not enough is known relative to the relationship of curve slopes to meat texture at present to adequately interpret these results. The variation among slopes classified on the basis of formula were greater than for any of the other main effects.

Data in Tables VII and VIII relate to area under the compression and shear slopes per gram of sample. Again, most of the differences among means were statistically significant, but an explanation of the practical significance is not available.

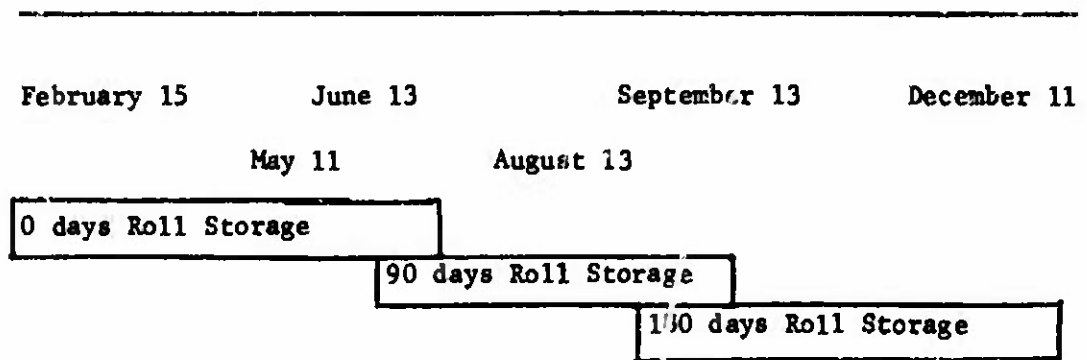
Tables IX and X list mean values and analyses of variance summaries for total area under the curve and peak heights, each per gram of sample weight. For the total area under the curve per unit weight the situation is about the same as for data in Tables V through VIII. Peak height per unit weight is the value used for years in reporting shear values on meat samples. The mean squares for formula were almost four times larger than the next highest value which was source. Although both carcass age and roll age means were significantly different among the storage periods, the magnitude of the differences was too small to be of practical importance.

## CONCLUSIONS

Based on results of this study, as much wider differences in the several quality attributes were found for source of turkey carcasses than for age of carcass or age of roll, it would appear logical to extend the usable shelf-life of frozen carcasses to 180 days.

Attention should be given to improving the formulation of precooked turkey rolls so that acceptability scores would be improved.

Figure 1. Seasonality of turkey meat evaluation as related to panel experience and age of prepared rolls.



Evaluation panels by months and cumulative

	<u>No.</u>	<u>Cumulative total</u>
February	3	3
March	4	7
April	2	9
May	3	12
June	7	19
July	2	21
August	3	24
September	7	31
October	2	33
November	0	--
December	3	36

Table I. Mean organoleptic scores for turkey rolls classified by main parameters examined.

<u>Carcass age</u>	<u>Flavor</u>	<u>Odor</u>	<u>Texture</u>	<u>Appearance</u>	<u>Color</u>
<30 days	6.04	5.95	6.18	5.16	5.48
90 days	5.73	5.79	5.80	4.79	5.17
130 days	5.85	5.93	6.08	5.08	5.40
180 days	5.81	5.77	6.14	5.30	5.65
<u>Source</u>					
Ohio	6.04	5.99	6.21	5.22	5.54
Indiana	5.90	5.89	6.00	4.81	5.25
Arkansas	5.65	5.70	5.94	5.22	5.49
<u>Formula</u>					
A	6.59	6.38	6.76	6.68	6.67
B	5.10	5.29	6.09	5.72	5.86
C	6.32	6.31	6.23	4.60	5.05
D	5.43	5.46	5.13	3.33	4.13
<u>Roll age</u>					
0 days	5.63	5.69	5.85	4.63	5.06
90 days	5.75	5.72	5.92	5.17	5.59
180 days	6.20	6.17	6.38	5.45	5.63
<u>Replicates</u>					
1	5.91	5.88	6.01	5.04	5.38
2	5.82	5.84	6.09	5.12	5.47

Table II. Summary of analyses of variance for organoleptic evaluations of turkey rolls

Source	df	Mean Squares				
		Flavor	Odor	Texture	Appearance	Color
Roll age (R)	2	8.54***	6.87***	7.80***	16.81***	9.79***
Formula (F)	3	36.07***	22.74***	33.00***	150.48***	85.15***
Source (S)	2	3.65*	1.95	1.94*	5.36**	2.28
Carcass age (C)	3	1.23	0.66	2.19**	3.32*	2.83*
R x F	6	1.52	2.11	0.20	0.57	1.04
R x S	4	0.65	1.22	0.65	2.09	0.64
R x C	6	0.78	0.24	0.73	0.80	0.20
F x S	6	1.23	1.36	0.18	0.20	0.14
F x C	9	0.80	0.23	0.52	1.06	0.40
S x C	6	4.27*	3.94***	2.48***	3.64**	1.83*
Error	96	1.08	0.64	0.54	0.97	0.74
Residual	144	0.34	0.26	0.29	0.44	0.33

\*p<0.05

\*\*p<0.01

\*\*\*p<0.001

\*\*\*\*p<0.0005

Table III. Mean values for TBA test and for Hunter Color meter readings classified by main parameters investigated.

<u>Carcass age</u>	<u>TBA</u>	<u>Hunter Color Meter</u>		
		<u>L</u>	<u>A</u>	<u>B</u>
<30 days	4.00	62.56	3.45	12.08
90 days	3.71	61.95	3.36	11.66
130 days	3.49	61.95	4.13	11.71
180 days	3.61	62.34	3.44	12.12
<u>Source</u>				
Ohio	3.90	63.38	3.93	12.21
Indiana	3.23	61.77	3.63	11.92
Arkansas	3.99	61.94	3.22	11.54
<u>Formula</u>				
A	3.63	64.68	3.66	11.80
B	5.88	62.82	3.40	11.89
C	2.37	62.24	3.77	11.83
D	2.94	59.71	3.55	12.05
<u>Roll age</u>				
0 days	3.74	62.93	3.66	11.93
90 days	3.56	61.80	3.13	12.01
180 days	3.81	62.56	4.00	11.67
<u>Replicates</u>				
1	3.97	62.60	3.58	11.92
2	3.44	62.13	3.51	11.86

Table IV. Summary of analyses of variance for TBA and Hunter Color Meter readings on turkey rolls

Source	df	Mean Squares		
		TBA	Hunter Color Meter	
			L	A B
Roll age (R)	2	1.53	30.82	18.53*** 3.44
Formula (F)	3	170.43***	303.02***	1.84 0.90
Source (S)	2	16.38	74.60*	12.04** 10.76***
Carcass age (C)	3	3.49	6.33	3.32** 4.19*
R x F	6	0.47	55.02	0.35 2.78
R x S	4	3.75	33.91	6.56** 2.13
R x C	6	2.05	35.91	4.75* 1.08
F x S	6	25.60***	37.13	2.63 1.74
F x C	9	7.73	43.63	1.08 1.91
S x C	6	5.17	72.81**	8.73 0.88
Error	96	5.52	21.92	1.74 1.26
Residual	144	1.91	13.43	0.71 0.86

\*P<0.05

\*\*P<0.01

\*\*\*P<0.001

\*\*\*\*P<0.0005

Table V. Mean values and standard errors for slope of compression curve and slope of shear curve classified by main parameters investigated.

<u>Carcass age</u>	<u>Compression</u>		<u>Shear</u>	
	<u>Curve</u>	<u>S.E.</u>	<u>Curve</u>	<u>S.E.</u>
<30 days	81.59	0.773	-71.50	1.250
90 days	79.91	0.746	-63.50	1.205
130 days	82.18	0.767	-67.02	1.240
180 days	82.95	0.744	-70.12	1.203
<u>Source</u>				
Ohio	80.00	0.666	-58.94	1.077
Indiana	81.77	0.643	-67.86	1.039
Arkansas	83.19	0.659	-77.31	1.066
<u>Formula</u>				
A	82.85	0.752	-57.46	1.215
B	94.06	0.768	-77.43	1.242
C	77.33	0.784	-56.98	1.268
D	72.38	0.725	-80.27	1.173
<u>Roll age</u>				
0 days	81.85	0.702	-64.39	1.135
90 days	84.56	0.629	-68.58	1.018
180 days	78.56	0.635	-71.14	1.026



Table VI. Summary of analyses of variance of data on slopes, compression curves and shear curves of turkey rolls.

<u>Source</u>	<u>df</u>	<u>Mean Squares</u>	
		<u>Compression curve</u>	<u>Shear curve</u>
Carcass age (C)	3	596*	4,435****
Formula (F)	3	30,373****	55,173****
Source (S)	2	1,162**	38,329****
Roll age (R)	2	4,510****	5,116****
C x S	6	1,888****	12,254****
C x R	6	1,637****	1,442*
C x F	9	1,587****	3,081****
S x R	4	1,351****	1,992**
S x F	6	1,771****	3,399****
R x F	6	443*	863
Remainder (Error)	1,377	199	521

\*P<0.05

\*\*P<0.01

\*\*\*P<0.001

\*\*\*\*P<0.0005

Table VII. Mean values and standard errors for area under the compression curve per gram of sample and area under the shear curve per gram of sample classified by main parameters investigated.

<u>Carcass age</u>	<u>Area of compression</u> <u>curve/g sample</u>		<u>Area of shear</u> <u>curve/g sample</u>	
	<u>Mean</u>	<u>S.E.</u>	<u>Mean</u>	<u>S.E.</u>
<30 days	0.991	0.012	0.864	0.013
90 days	0.917	0.011	0.889	0.013
130 days	0.965	0.011	0.877	0.013
180 days	0.996	0.011	0.875	0.013
<u>Source</u>				
Ohio	0.869	0.010	0.867	0.011
Indiana	1.004	0.010	0.869	0.011
Arkansas	1.029	0.010	0.892	0.011
<u>Formula</u>				
A	0.908	0.011	0.895	0.013
B	1.114	0.011	1.071	0.013
C	0.856	0.012	0.777	0.013
D	0.992	0.011	0.760	0.012
<u>Roll age</u>				
0 days	0.927	0.010	0.986	0.012
90 days	1.000	0.009	0.881	0.011
180 days	0.974	0.009	0.761	0.011

Table VIII. Summary of analyses of variance of data relative to area of compression curve per gram of sample and area under the shear curve per gram of sample of turkey rolls.

<u>Source</u>	<u>df</u>	<u>Mean Squares</u>	
		<u>Compression</u>	<u>Shear</u>
Source (S)	2	175.8****	8.2
Carcass age (C)	3	35.9****	5.1
Roll age (R)	2	22.8****	240.2****
Formula (F)	3	200.8****	387.6****
S x C	6	51.8****	25.6****
S x R	4	13.3****	20.9****
S x F	6	10.7**	8.7**
C x R	6	10.5**	10.8***
C x F	9	5.5**	14.9****
R x F	6	2.1	5.0
Remainder	1,377	2.2	2.9

\*P<.05  
 \*\*P<0.01  
 \*\*\*P<0.001  
 \*\*\*\*P<0.0005

Table IX. Mean values and standard errors for total area under the curve per gram of sample and of peak height per gram of sample classified by main parameters investigated.

<u>Carcass age</u>	<u>Total area/g sample</u>		<u>Peak height/g sample</u>	
	<u>Mean</u>	<u>S.E.</u>	<u>Mean</u>	<u>S.E.</u>
<30 days	3.20	0.033	4.06	0.041
90 days	3.19	0.032	3.90	0.040
130 days	3.20	0.032	3.87	0.041
180 days	3.29	0.032	4.01	0.040
<u>Source</u>				
Ohio	2.98	0.028	3.69	0.036
Indiana	3.34	0.027	4.01	0.034
Arkansas	3.33	0.028	4.18	0.035
<u>Formula</u>				
A	3.28	0.032	3.76	0.040
B	3.85	0.033	4.73	0.041
C	2.85	0.033	3.41	0.042
D	2.89	0.031	3.95	0.039
<u>Roll age</u>				
0 days	3.32	0.030	4.02	0.038
90 days	3.26	0.027	4.02	0.034
180 days	3.07	0.027	3.84	0.034

Table X. Summary of analyses of variance of data relative to total area under the curve per gram of sample and peak height per gram of sample of turkey rolls.

<u>Source</u>	<u>df</u>	<u>Mean Squares</u>	
		<u>Total area</u>	<u>Peak height</u>
Source (S)	2	18.58****	28.36****
Carcass age (C)	3	0.76	2.76**
Roll age (R)	2	7.90****	5.66****
Formula (F)	3	72.86****	105.39****
S x C	6	8.16****	17.80****
S x R	4	0.23	1.91*
S x F	6	3.02****	3.28***
C x R	9	0.26	1.70***
C x F	6	0.73	1.93***
R x F	6	0.36	1.02
Remainder	1,377	0.36	0.57

\*P < 0.05  
 \*\*P < 0.01  
 \*\*\*P < 0.001  
 \*\*\*\*P < 0.0005